APPARATUS AND METHOD FOR MUSCLE STRENGTHENING AND REHABILITATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus and method for assisting in muscle strengthening and rehabilitation.

2. Background Art

There exists today a multitude of devices and methods designed to assist in the strengthening and/or rehabilitation of various muscles and joints. Because of the frequency with which it is injured, the ankle is the focus of much effort in the area of rehabilitation. Current devices designed to assist in the rehabilitation of the ankle generally fall into two broad categories. The first of these includes devices with moveable foot plates having a variable resistance mechanism. The resistance is adjusted based on the strength of the ankle, and is applied by one of a number of different mechanisms. For example, hydraulic or pneumatic cylinders may be attached to the foot plate, whereby an adjustment of the cylinder increases or deceases the resistance felt by the patient's ankle. In simpler devices, a spring may be employed such that pre-tensioning the spring, or employing more than one spring with different stiffnesses, provides the desired resistance. Devices in this first group vary in complexity and are generally large and unwieldy. This makes these devices a poor choice for the patient who wishes to pursue rehabilitation or muscle strengthening in the home. Moreover, increasing the complexity of the device necessarily increases the cost, thereby making it uneconomical for many patients to purchase such a device for home use.

The second broad category into which ankle strengthening and rehabilitation devices are grouped comprises the family of devices having flat boards or foot plates for an upper surface and curved elements for a lower surface. The

curved lower surface facilitates pivotal movement of the patient's ankle. One such device is found in U.S. Patent No. 5,722,919 issued to Timmer on March 3, 1998. Timmer teaches a foot plate with a moveable weight attached to the bottom, such that the patient can strengthen the ankle by adding additional weight or moving the location of the weight. As an alternative, the weight is replaced with a semi-spherical ball, the flat portion of which abuts the bottom of the foot plate. By its nature, a semi-spherical ball has a constant radius in all directions; therefore, a patient using this device will move the ankle with the same radius of curvature regardless of the direction of the movement. For example, a plantar flexion/dorsi flexion exercise, characterized by a front to back rotation of the ankle, is necessarily carried out along the same radius of curvature as an inversion/eversion exercise, which is characterized by a side-to-side rotation of the ankle. This limitation is inherent in the nature of the semi-spherical ball, which provides for the same radius of curvature for a motion in any direction.

Another exercise device falling into the latter of the two categories is found in U.S. Patent No. 5,643,164 issued to Teff on July 1, 1997. Teff teaches a rocker board, the bottom of which contains two arc shaped members. The patient stands on the rocker board aligning the feet such that they are either parallel to the arched members or perpendicular to them. An obvious limitation to this device is that the patient who is engaging in a plantar flexion/dorsi flexion exercise must reorient the feet 90° to perform an inversion/eversion exercise. Unlike the semi-spherical ball disclosed in Timmer, movement of the rocker board is constrained along a single line. In addition, the rocker board also has a single, fixed radius of curvature that forces the patient to use the same pivotal motion for each exercise.

Accordingly, it is desirable to provide a muscle strengthening and rehabilitation apparatus, and a method for using the apparatus, which overcome the above referenced shortcomings of prior art methods by reducing the complexity and the cost of the apparatus, thereby making it suitable for use in the home, and at the same time providing an increased range of motion to maximize efficacy.

SUMMARY OF THE INVENTION

Therefore, it is an object of the invention to provide an improved muscle strengthening and rehabilitation apparatus having a range of motion sufficient to strengthen and rehabilitate a wide variety of muscles and joints.

It is another object of the present invention to provide a muscle strengthening and rehabilitation apparatus that is inexpensive and lacks complexity so that it can be effectively utilized in the patient's home.

It is still another object of the present invention to provide a method for utilizing the apparatus, wherein exercises involving movement of an extremity in any direction can be accommodated.

Accordingly, a muscle strengthening and rehabilitation apparatus is provided which includes a first surface for receiving an injured extremity, and a generally hemi-ellipsoidal second surface for contacting a support surface. The second surface allows for pivotal movement of the extremity in any direction, where the radius of curvature of the movement varies depending upon the direction the extremity is pivoted.

In another aspect of the present invention, an exercise apparatus is provided which is made from a one-piece construction, and includes an upper surface for receiving the patient's extremity and a convex lower surface for contacting a support surface. The lower surface has a plurality of different radii which allows the patient to pivot the extremity about the lower surface in any direction, such that exercises utilizing the different radii can be performed without reorienting the extremity on the upper surface.

In yet another aspect of the present invention, the muscle strengthening and rehabilitation apparatus comprises a unitary polyethylene foam structure having a density greater than 2.5 lbs. per cubic foot. The foam structure has a generally flat first surface with a length of approximately 13.5 inches, intended

to receive the patient's extremity. The foam structure also has a substantially hemi-ellipsoidal second surface for contacting a support surface. The contact of the second surface and the support surface creates a contact point on the second surface. Pivotal movement of the extremity changes the position of the contact point to allow for movement in any direction, where the radius of curvature of the movement varies depending upon the direction the extremity is pivoted.

In a preferred embodiment, the first surface is generally elliptical, having a major diameter and a minor diameter. A thickness is defined as the distance from the first surface to the second surface measured along a line approximately normal to the first surface and passing through the intersection of the major and minor diameters, where the length of the major diameter is about 13.5 inches, the length of the minor diameter is about 6.0 inches, and the thickness is about 3.0 inches. A plate can be attached to the first surface, and a circumferential band can be included to provide a smooth transition between the flat upper surface and the convex lower surface. In addition, the lower surface can include a flat area which allows the apparatus to remain stationary with the first surface oriented upward when the apparatus is not in use.

Correspondingly, a method of muscle strengthening and rehabilitation is provided which includes providing an apparatus with a first surface and a generally hemi-ellipsoidal second surface, disposing the apparatus between a patient's extremity, such as a foot or hand, and a support surface, such as a floor or wall, such that the extremity contacts the first surface and the second surface contacts the support surface, thereby creating a contact point on the second surface, and pivotally moving the extremity while it remains on the first surface, where the radius of curvature of the movement varies depending upon the direction the extremity is pivoted.

In still another aspect of the invention, a method of increasing proprioception is provided which includes providing an apparatus with a first surface and a generally hemi-ellipsoidal second surface, disposing the apparatus between the patient's foot and a support surface, where the extremity contacts the

first surface and the second surface contacts the support surface, and shifting at least a portion of the patient's weight to the foot on the first surface such that the patient must at least partially balance on the apparatus.

The above object and other objects, features, and advantages of the present invention are readily apparent from the following detailed description of the best modes for caring out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a perspective view of a muscle strengthening and rehabilitation apparatus in accordance with the present invention;

FIGURE 2 is a side elevational view of the apparatus shown in Figure 1;

FIGURE 3 is a front elevational view of the apparatus shown in Figure 1;

FIGURE 4 is a top plan view of the apparatus shown in Figure 1;

FIGURE 5 is an illustration of the apparatus being used in a first ankle rehabilitation exercise, showing a patient lying on a floor and the apparatus located between the patient's foot and a wall;

FIGURE 6 is an illustration of the apparatus being used in a second ankle rehabilitation exercise, showing the patient sitting on a chair and the apparatus located between the patient's foot and a floor;

FIGURE 7 is an illustration of the apparatus being used in a third ankle rehabilitation exercise, showing the patient standing with upper and lower extremity support and the apparatus located between the patient's foot and the floor;

FIGURE 8 is an illustration of the apparatus used in a fourth ankle rehabilitation exercise, showing the patient standing with only upper extremity support and a towel wrapped around the apparatus, which is located between the patient's foot and the floor;

FIGURE 9 is an illustration of the apparatus used in a fifth ankle rehabilitation exercise, showing the patient standing on the apparatus with no support;

FIGURE 10 is an illustration of the apparatus used in a first shoulder rehabilitation exercise, showing the apparatus located between a patient's hand and a table;

FIGURE 11 is an illustration of the apparatus used in a second shoulder rehabilitation exercise, showing the apparatus located between the patient's hand and a wall; and

FIGURE 12 is an illustration of the apparatus used in a third shoulder rehabilitation exercise, showing the apparatus located between the patient's hand and the floor.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a perspective view of a muscle strengthening and rehabilitation apparatus 10 in accordance with the present invention. A first, upper surface 12 of the apparatus 10 is constructed to be generally flat, so as to easily receive a patient's hand or foot, especially when the patient is wearing a flat soled shoe. However, it is understood that the upper surface 12 can be made generally concave or convex so as to approximate the contour of the extremity being received. As used here, the word "extremity" is not limited to a patient's limb, but rather contemplates virtually any part of the patient's body. This means that the apparatus 10 can also be used to effectively exercise and strengthen the scapular stabilizers,

hip girdle musculature, and the core stabilizers, such as the abdominal or back muscles.

The upper surface 12 is also generally elliptical, as is more clearly illustrated in Figures 2-4. The upper surface 12 is shown herein with flattened ends 14 rather than the rounded ends generally associated with an ellipse. This aspect of the embodiment is driven primarily by manufacturing considerations, which dictate that unnecessary material should be eliminated; however, the upper surface can be made into a full ellipse or even other geometric shapes.

The apparatus 10 also includes a second, lower surface 16 which is shaped approximately like a hemi-ellipsoid. Lower surface 16 is designed to contact a support surface, typically a flat, stationary surface such as a wall or floor as described below with reference to Figures 5-12. The shape of the lower surface 16 provides different radii of curvature for different directions of motion. This is clearly illustrated in Figures 2 and 3. The generally elliptical perimeter of the upper surface 12 compliments the hemi-ellipsoidal shape of the lower surface 16. That is, the length of the upper surface 12, shown as "L" in Figure 4, coincides with the largest radii of curvature of the lower surface 16. Similarly, the width of the upper surface 12, shown as "W" in Figure 4, coincides with the smallest radius of curvature of the lower surface 16.

The generally elliptical perimeter of the upper surface 12 serves a variety of functions. First, because it is substantially longer than it is wide, the upper surface 12 provides an adequate surface to accommodate even a large extremity without using unnecessary material. Moreover, proper orientation of the patient's foot ensures a large radius of curvature in a plantar flexion/dorsi flexion exercise and a smaller radius of curvature in an inversion/eversion exercise. In addition, the upper surface 12 is long enough to accommodate both of the patient's hands, yet narrow enough to allow the patient's fingers to reach over the edge. This is particularly useful in a shoulder exercise that calls for a completely unstable surface, the benefits of which are described more fully below.

As shown in Figures 1, 2 and 3, the apparatus 10 also has a flat narrow surface 18 circumnavigating the perimeter of the upper surface 12. The flat surface 18 facilitates a smooth transition between the flat upper surface 12 and the convex lower surface 16. Designing the apparatus 10 to include the flat circumferential band 18 ensures that the outer perimeter of the upper surface 12 is not characterized by a very thin section of material that includes a relatively sharp edge. The circumferential band 18 is not required, but does help to eliminate unnecessary material from the finished product.

In a preferred embodiment, the apparatus 10 is manufactured in a one-piece construction and is made from a lightweight material, such as polyethylene foam; of course, other polymers such as polypropylene, polyurethane, and polystyrene can be used. The material needs to be strong enough and dense enough to accommodate weight bearing by even a large patient. A patient weighing more than 250 lbs. can be supported by the apparatus if it is made from a cross-linked polyethylene foam having a density greater than about 2.5 lbs. per cubic foot, and most preferably about 3 lbs. per cubic foot. Referring to Figure 4, the upper surface 12 of the preferred embodiment is approximately 13.5 inches long and 6.0 inches wide. This allows enough surface area to accommodate a large patient's foot, as well as both of the patient's hands when both shoulders are exercised simultaneously.

The apparatus also has a thickness, shown as "T" in Figure 3, that in a preferred embodiment is approximately 3.0 inches. This thickness ensures that there will be enough foam to adequately support the patient's entire weight, and also raises the upper surface 12 far enough away from the support surface so that the extremity can be exercised with a full range of motion. In Figures 2 and 3 it is seen that the apparatus 10 contains on the lower surface 16 a small flat area 20. The flat area 20 is large enough to allow the apparatus 10 to remain in an upright position when the apparatus 10 is not in use. At the same time, the flat surface 20 is small enough so that its presence does not impede smooth movement of the apparatus 10 as the extremity is exercised through the full range of motion.

In operation, the patient places an extremity such as a hand or a foot on the upper surface, while the lower surface contacts the support surface. This effectively traps the apparatus between the extremity and the support surface. The patient then pivots the extremity thereby rotating the apparatus along various points on the lower surface. Because of the shape of the lower surface, the patient is afforded a full tri-planar range of motion including different radii of curvature depending on the direction of the motion. As the patient applies a force to the extremity — e.g., by shifting body weight to the extremity or by pushing on the upper surface — the support surface provides a resistive force. The patient then pivots the extremity in directions most advantageous to strengthening and rehabilitation.

Exercises such as these where the extremity contacts a resistive force or surface, are commonly referred to as "closed chain" exercises. Specifically, the patient applies the load and generates movement at the distal end of the extremity. Because the load is applied through the entire kinetic chain, motion at the distal segment affects motion at the more proximal segments. The choice of which support surface to use is primarily dependent on the strength of the extremity or the severity of the injury to the extremity.

Turning now to Figure 5, a first ankle strengthening and rehabilitation exercise is shown. This exercise is performed soon after the patient's ankle has been injured and it is in its weakest state. The patient lies with his or her back on the floor, places the foot 22 having the injured ankle on the upper surface 12 of the apparatus 10. The lower surface 16 of the apparatus 10 is placed against a wall 24 which provides a resistive force felt by the patient's foot 22. This is the only force on the foot 22, since this is a non-weight bearing exercise. The patient then pivots the foot 22 around the injured ankle while applying a force to the apparatus 10, as shown by the dotted lines in Figure 5. The benefit of exercise in this position is twofold: first, elevating the ankle helps to reduce swelling, and second, the patient can only exert a limited amount of force in this position, which makes this exercise ideally suited to an ankle that has been recently injured. Moreover, this exercise facilitates tri-planar range of motion in the ankle, which is

important since most daily activities require the ankle to function in all three planes. In addition, the lightweight polyethylene foam construction of the apparatus 10 allows the patient to easily trap the apparatus 10 between the foot 22 and the wall 24 with only a minimum of force applied by the foot 22.

This exercise also begins the process of proprioceptive feedback in the ankle. That is, the patient starts to regain awareness of the ankle's position and the level and direction of the loads bearing on the ankle. This is very important, since many recurring injuries are caused not by a lack of strength in the ankle, but rather because the sensory receptors are not functioning well, which can lead to errors in judgment as to the position and loading of the ankle. The end result is often a misapplication of a force on the ankle, leading directly to re-injury.

Another aspect of the method of the present invention, illustrated in Figure 6, includes an intermediate level exercise designed to be used after the injured ankle has had some time to recover. The patient sits on a chair and places the foot 22 associated with the injured ankle on the top surface 12 of the apparatus 10. The lower surface 16 is placed on a floor 26 which provides the necessary resistive force to the foot 22. Here, by shifting at least a portion of the body weight to the foot and ankle area, the patient can apply a force to the apparatus 10 that is greater than when it is placed on the wall 24. This increases the resistive force felt by the muscles and joints, and provides a natural transition to the ultimate goal of full weight bearing. Again the patient pivots the foot 22 around the injured ankle in a full range of motion, illustrated by the dotted lines in Figure 6, thereby further strengthening and rehabilitating the injured ankle. This exercise increases proprioceptive feedback and prepares the kinetic chain for progression to full weight bearing.

Figure 7 shows a further progression in the ankle strengthening and rehabilitation regime. The patient stands with the aid of upper extremity support, for example by placing his or her hands on the back of a chair 27. The foot 22 associated with the injured ankle is placed on the upper surface 12 of the apparatus 10. The lower surface 16 of the apparatus 10 is placed on the floor 26 which

provides the necessary resistive force to the foot 22. In this example, the foot 28 associated with the healthy ankle bears most of the patient's weight. As the rehabilitation of the injured ankle progresses, the patient places increasing amounts of weight on the foot 22 while it pivots around the injured ankle, and the patient continues to exercise the ankle throughout the full range of motion.

Upon further rehabilitation of the ankle, the patient can place 100% of body weight on the foot 22 by lifting the other foot 28 completely off the floor. This is illustrated in Figure 8. In this initial transfer of all the body weight to the injured ankle, the patient continues to rely on the upper extremities for balance. Prior to this initial transfer of all of the body weight onto the foot 22, the patient can place a towel 30 around the lower surface 16 of the apparatus 10. This limits the apparatus's motion, which is important since the ankle is still in a relatively weak state. The full weight bearing that is allowed with this exercise brings the entire kinetic chain into effect — i.e., the ankle, knee, and hip musculature are all at work. Eventually, the towel 30 can be removed as the injured ankle become progressively stronger.

Figure 9 shows yet a further progression in the ankle strengthening and rehabilitation regime. The patient stands with the foot 22 placed on the upper surface 12 of the apparatus 10. The lower surface 16 of the apparatus 10 is placed on the floor 26. The patient then lifts the foot 28 completely off the floor 26 and does not use the upper extremities to assist in balancing. This allows the patient to be tested in a very unstable position on an unstable surface. This exercise also provides excellent proprioceptive feedback. That is, the patient experiences a heightened awareness of the sensory receptors such as the Golgi-type endings, Golgi-Mazzoni corpuscles, Ruffini corpuscles, and the free nerve endings. Increasing proprioception by the method of the present invention trains the sensory receptors at a very high level, making it much easier to return to normal activities.

In a regime similar to the exercise of the ankle, the patient's shoulder can also be exercised using the apparatus. Figure 10 illustrates an exercise designed

for rehabilitation of a recently injured shoulder. The lower surface 16 of the apparatus 10 is placed on a table 32. The patient places his or her hand 34 on the upper surface 12 of the apparatus 10. The patient than applies a downward force to the hand 34 while pivoting the apparatus 10 around the lower surface 16. This exercise benefits the shoulder by providing proprioceptive feedback throughout the joint. Causing joint compression with a force applied to an unstable surface — i.e., the apparatus 10 — initiates co-contraction of the shoulder girdle musculature. This in turn helps to stabilize the scapula, providing support for the upper extremity.

Figure 11 illustrates the next step in the progression of shoulder exercises which are possible using the apparatus 10 of the present invention. The lower surface 16 of the apparatus 10 is placed against the wall 24. The patient's hand 34 is placed on the upper surface 12 of the apparatus 10 such that the apparatus 10 is now located between the patient's hand 34 and the wall 24. The patient again applies a force to the hand 34 and pivots the apparatus 10 around the lower surface 16 utilizing the full range of motion afforded by the apparatus 10. This exercise provides continued proprioceptive feedback throughout the shoulder girdle, and also allows protraction and retraction of the shoulder on the unstable surface provided by the apparatus 10.

A further step in the shoulder exercise regime is illustrated in Figure 12. The lower surface 16 of the apparatus 10 is placed on the floor 26. While kneeling, the patient's hand 34 is placed on the upper surface 12 of the apparatus 10. In this way a greater force can be applied to the hand 34 as the apparatus 10 is pivoted about its lower surface 16. This exercise provides a further progression allowing for increased joint compression and increased proprioceptive feedback. It should be noted that each of the shoulder exercises illustrated in accordance with the present invention can be performed with both of the patient's hands placed on the upper surface 12 of the apparatus 10. This provides a surface that is even more unstable since neither of the patient's hands are placed on a stationary support surface such as the floor. Decreasing the stability increases the co-contraction and the proprioceptive feedback which provides additional benefit to the patient.

Therefore, the present invention provides an effective muscle strengthening and rehabilitation apparatus suitable for use by a patient in the home because of its simple, low cost design. The apparatus and method can be used to strengthen and rehabilitate a wide variety of muscles and joints, including ankles, knees and shoulders. Of course, it is understood that exercises for the ankle and shoulder using apparatus 10 other than those described herein, as well as exercises for other parts of the body, are fully contemplated in the present invention.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.